



**US Army Corps  
of Engineers**  
Engineering and Support  
Center, Huntsville

# ***ORDNANCE & EXPLOSIVES TOOLBOX***



# ***Introduction***

- ❖ **Ordnance and Explosives (OE) Toolbox is a set of tools to enhance and ensure explosives safety at OE sites**
- ❖ **OE Toolbox includes:**
  - **Blast Effects Prediction Methods**
  - **Engineering Controls**
- ❖ **Developed as part of Huntsville Center's OE Innovative Technology Development Program**



# ***Available Tools***

## **❖ Blast Effects Prediction Methods**

- **Ordnance fragmentation characteristics**
- **Range to no more than 1 hazardous fragment/600 sq. ft.**
- **Consolidated Shots**

## **❖ Engineering Controls**

- **Buried Explosion Module**
- **Sandbag Enclosures**
- **Water Mitigation Method**
- **Barricades**
- **Donovan T-10 Transportable Blast Chamber**



## ***Prediction of Primary Fragmentation from Cased Munitions (HNC-ED-CS-S-98-1)***

- ❖ **Methodology for predicting fragmentation characteristics of cased, cylindrical munitions based on techniques in TM 5-1300**
- ❖ **Prediction based on explosive weight, case weight, and munition geometry**
- ❖ **Results: Maximum fragment weight, average fragment weight, total number of fragments, fragment weight for a given confidence level and initial fragment velocity**
- ❖ **Used to compute fragment distances, striking energy, areal distribution of fragments, and penetration**
- ❖ **Method approved by DDESB on 6 Apr 98 “for use in deciding Inhabited Building Distance (IBD) for primary fragments in site remediation activities”.**



## ***Hazardous Fragment (1/600) Distance (HNC-ED-CS-S-98-2)***

- ❖ Distance to exposure to one hazardous fragment per 600 square foot area
- ❖ Fragmentation characteristics IAW HNC-ED-CS-S-98-1
- ❖ Hazardous fragment density and distance computed as per NATO Safety Principles, AASTP 1 (AC/258-D/258)
- ❖ Simple computer program to compute 1/600 distance
  - HAZFRAG - DOS version
- ❖ Method and HAZFRAG approved by DDESB on 6 Apr 98 “for use in deciding Inhabited Building Distance (IBD) for primary fragments in site remediation activities”.



# ***Consolidated Shots***

- ❖ Procedure developed for multiple round detonation
- ❖ Munitions placed with sides touching such that their axis is horizontal with the nose of each pointing in the same direction
- ❖ Munitions oriented so that lugs, strong-backs, nose, and/or tail plate sections are facing away from personnel locations
- ❖ Minimum separation distance will be the greater of
  - Overpressure distance (K328) based on total NEW of all munitions plus the initiating explosives
  - Appropriate fragment range as determined by the maximum fragment range or the mitigated fragment range based on the worst case munition in the shot
- ❖ Approved by DDESB 27 October 1998



## ***Buried Explosion Module (HNC-ED-CS-S-97-7, Rev. 1)***

- ❖ Calculate required withdrawal distances for intentional detonations that use earth cover for fragmentation mitigation
- ❖ Compute maximum fragment characteristics IAW HNC-ED-CS-S-98-1
- ❖ BEM has been automated in a simple computer program
  - For a given round, burial depth and soil type,
  - Determine whether a crater or a camouflet is formed
  - Compute the residual velocity of the fragment
  - Compute maximum soil ejecta radius
- ❖ BEM method and computer program have been approved by DDESB on 3 November 1998 “for deciding public and operation withdrawal distances during ordnance and explosives (OE) operation involving intentional detonations”.



# ***Sandbag Enclosures for Fragment Mitigation (HNC-ED-CS-S-98-7)***

- ❖ **Procedures and guidelines for using sandbags to reduce fragment distances for intentional detonations**
- ❖ **Based on 1997-1998 testing program**
- ❖ **Procedures include:**
  - **Required thickness of sandbags needed to capture all fragments**
  - **Sandbag throw distances**
  - **Enclosure construction details**
- ❖ **Valid for munitions up to 155mm**
- ❖ **Guidelines approved by DDESB on 23 February 1999 “to mitigate hazards and protect personnel from intentional detonations of munitions up to the 155-mm M107.”**





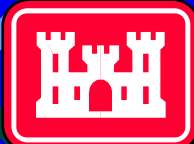
## ***Water Mitigation of Fragments & Blast Effects From Intentional Detonations (HNC-ED-CS-S-00-3)***

- ❖ Procedures and guidelines for using water to reduce fragment distances for intentional detonations
- ❖ Based on 1999 testing program
- ❖ Procedures include:
  - Required thickness/depth of water needed to defeat all fragments
  - Water container throw distances
  - Construction details
- ❖ Valid for munitions up to 155mm
- ❖ Guidelines approved by DDESB on 27 February 2001 “for field use in Ordnance Explosives (OE) removal action projects.”



# *1100 gallon Agricultural Tank*





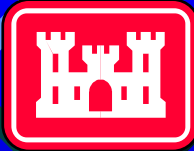
## ***5 gallon Carboys over an 81-mm***





# ***Post Detonation of 60-mm Under an Inflatable Pool***





## ***Initiation of Detonation for Sandbags and Water Methods***

- ❖ **Original tests were done using commercial shaped charges to initiate detonation.**
- ❖ **All information provided on MSD calculation sheet is based on use of commercial shaped charge.**
- ❖ **2001 tests using C-4 donor charge to initiate 155 mm under sandbags show that no more than 1 block (1.25 lbs) of C-4 can be used.**
- ❖ **Use of C-4 or a booster to initiate detonations requires a new MSD calculation sheet based on the amount of donor charge.**



# ***Standard Designs of Barricades***

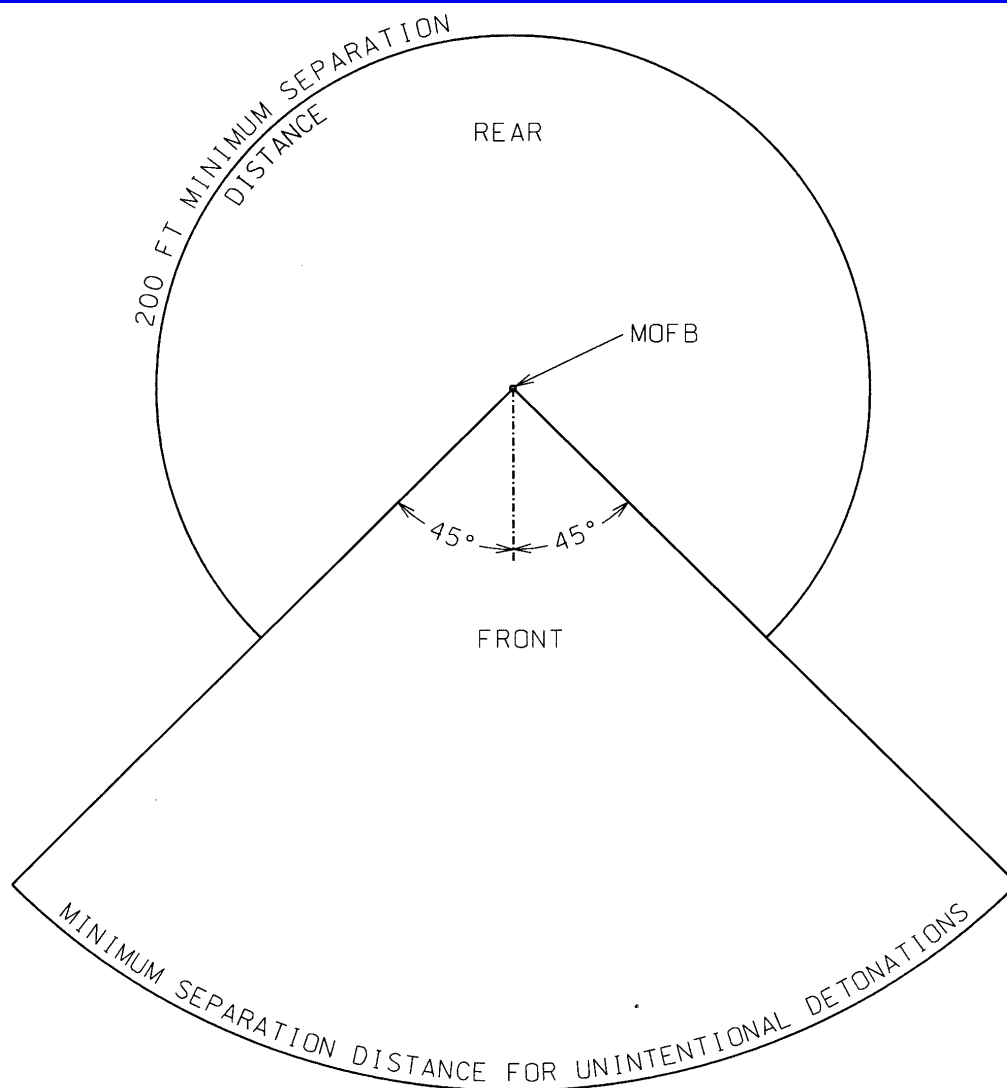
- ❖ **Developed a series of standard barricades for fragment mitigation during excavation and removal of OE items**
- ❖ **Provide fragment protection from accidental detonations**
- ❖ **Barricade Types:**
  - **Open Front Barricade**
  - **Enclosed Barricade**
  - **Miniature Open Front Barricade (“Bud-Light”)**
  - **Trailer-Mounted Bud-Light**
  - **Plate Barricade**
  - **Bulk Barricade**
  - **Modular Sandbag Barricade**



## ***Miniature Open Front Barricade ("Bud Light") (HNC-ED-CS-S-98-8)***

- ❖ **Developed a standard barricade for fragment mitigation during excavation of OE items up to an 81 mm mortar**
- ❖ **Provide fragment protection from unintentional detonations**
  - **Reduces separation distance due to fragmentation on three sides**
  - **Does not reduce separation distance out open front**
  - **Not designed to mitigate effects from blast overpressure or noise**
  - **Not intended for reuse after an accident**
- ❖ **Constructed of 1/4 aluminum plates welded together to form a basic barricade with aluminum channels to hold additional plates**
- ❖ **3 ft square footprint, 3 ft tall in front sloping to 2 ft in rear**
- ❖ **Miniature Open Front Barricade approved by DDESB on 23 February 1999**





MINIMUM SEPARATION DISTANCE FOR UNINTENTIONAL DETONATIONS  
USING MINIATURE OPEN FRONT BARRICADE DURING INTRUSIVE ACTIVITIES

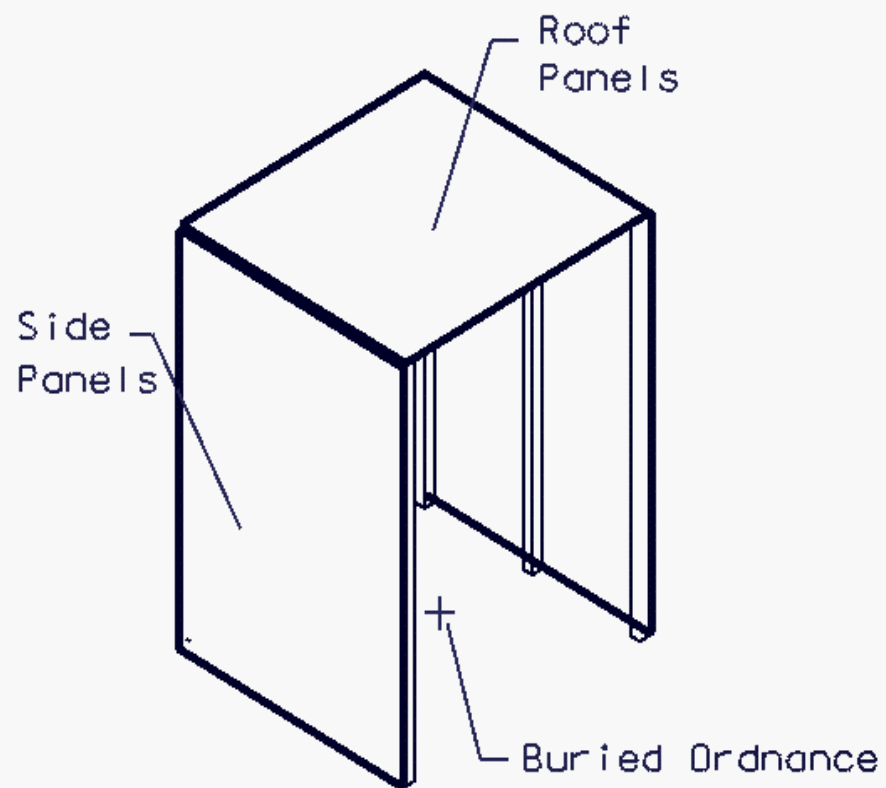


# ***Open Front & Enclosed Barricades (HNC-ED-CS-S-99-1 Terminology Update March 2000)***

- ❖ **Provide fragment protection from unintentional detonations**
  - **Open front reduces separation distance due to fragmentation on 3 sides, enclosed on 4 sides**
  - **Open front does not reduce separation distance out open front**
  - **Not designed to mitigate effects from blast overpressure or noise**
  - **Not intended for reuse after an accident**
  - **Holds a maximum of 2.75 inches of aluminum plate**
- ❖ **Frame constructed of square tubing with pins to hold aluminum plates**
- ❖ **4 ft square footprint, 6 ft tall**
- ❖ **Open Front & Enclosed Barricades approved by DDESB on 9 December 1999**

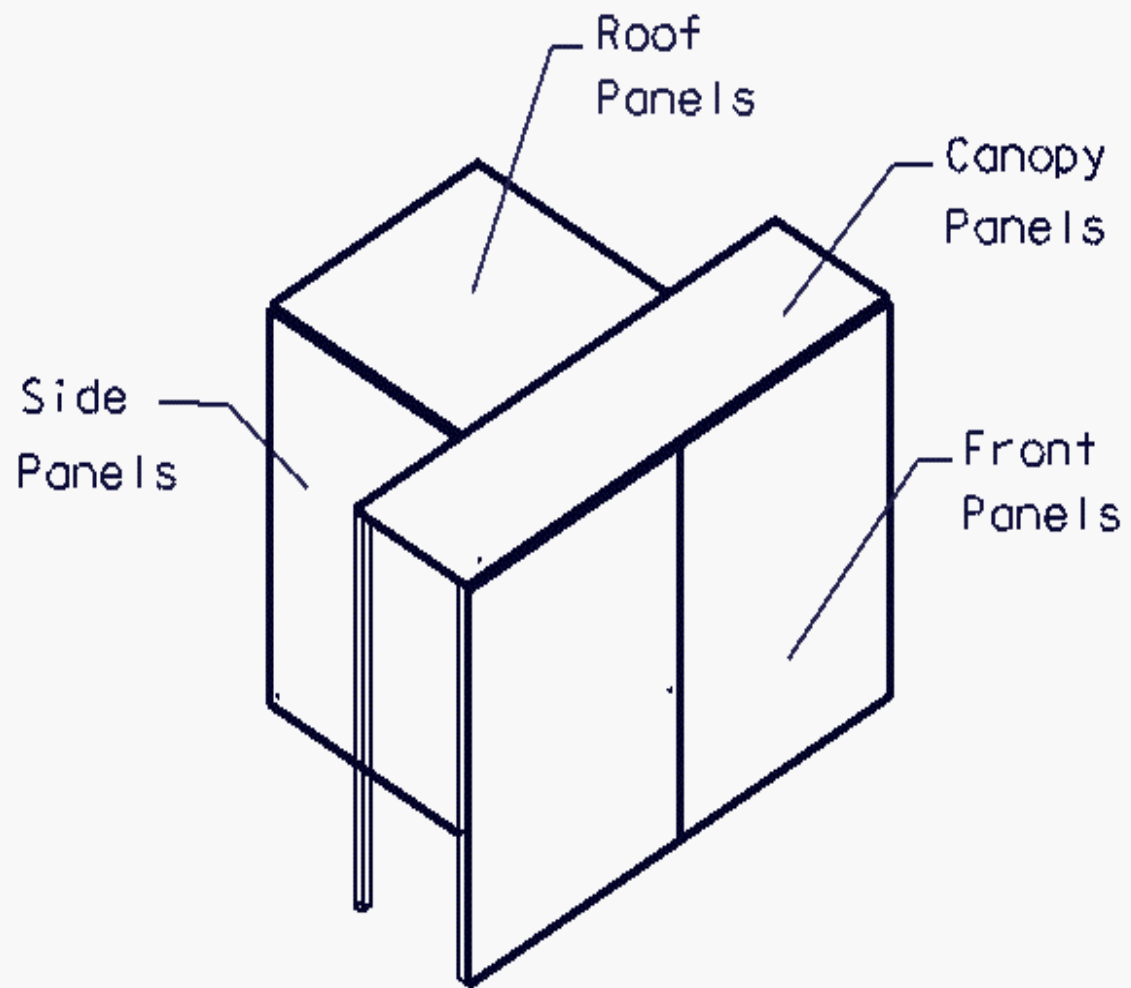


## OPEN FRONT BARRICADE





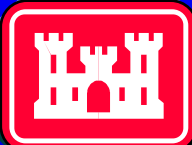
## ENCLOSED BARRICADE





## ***Donovan T-10 Transportable Blast Chamber***

- ❖ **Commercially developed by DeMil International**
- ❖ **Alternative to open detonation or transportation of recovered ordnance to a remote site**
- ❖ **Used to intentionally detonate ordnance items ranging in size up to and including the 81 mm HE mortar rounds**
- ❖ **Maximum NEW 10 lbs HMX (13 lbs TNT)**
- ❖ **Noise levels from 10 lbs HMX detonation inside T-10 are approximately 130 dB at 30 ft**
- ❖ **Air Pollution Control Unit attached to system**
- ❖ **Approved by DDESB 31 January 2000**



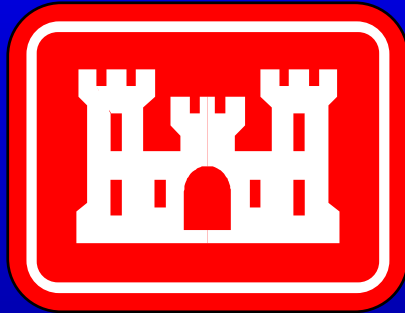
# ***Donovan T-10 Transportable Blast Chamber***





## ***OE Toolbox Location***

- ❖ **The virtual location for the OE Toolbox is Huntsville Center's Internet Web Site**
  - **[www.hnd.usace.army.mil/oew/tech/AnalyticalTools/analindx.htm](http://www.hnd.usace.army.mil/oew/tech/AnalyticalTools/analindx.htm)**
  - **Must complete form requesting access first time**
  - **Can download reports and software**
  - **Can access report summaries (Index) without password**
- ❖ **Password protected area of website is down at this time.**



# **US Army Corps of Engineers**

Engineering and Support  
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# ***105mm Fragment Characteristics***

Region	Maximum Fragment Weight (lb)	Initial Fragment Velocity (fps)	Max Fragment Range (ft)	Hazardous (1/600) Fragment Range (ft)
A	0.206	4055	1939	341
B	0.155	4870	1869	
C	0.086	5175	1590	
D	0.096	4021	1548	



## ***105mm Example***

❖ 105 mm M1, 5.08 lbs Comp B, buried in Wet Sandy Clay

Depth of Burial (ft)	Crater or Camouflet	Residual Fragment Velocity (fps)	Max Soil Ejecta Radius (ft)	Primary Fragment Range (ft)
3	Crater	189	165	495
3.5	Crater	114	168	270
4	Crater	68	170	125
4.5	Crater	41	172	50
5	Camouflet	25	0	20



## ***Sandbag Results***

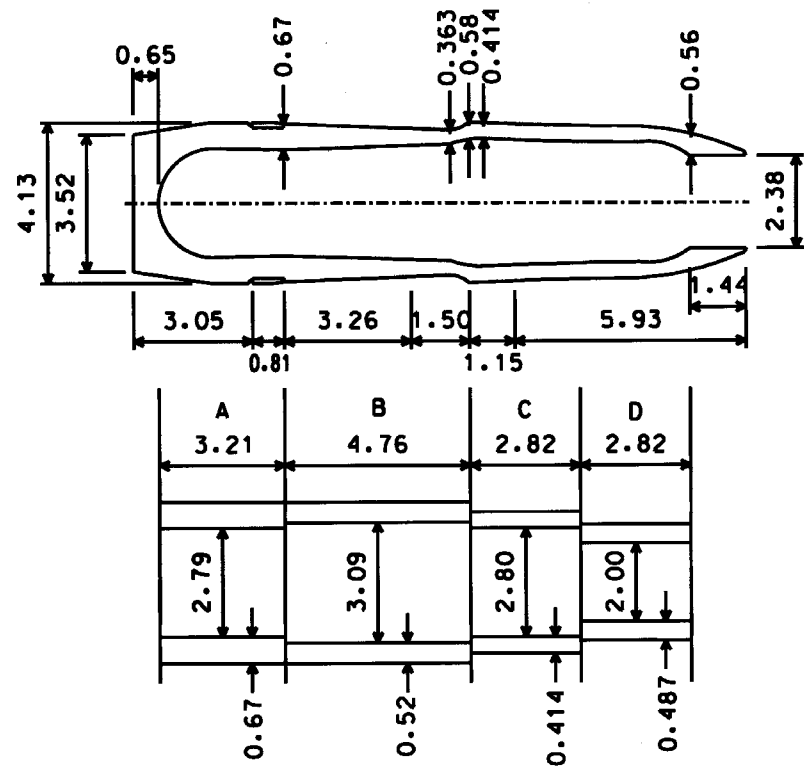
Munition	Charge Weight	Sandbag Thickness (in)*	Max Sandbag Throw Distance (ft)**
155-mm M107	15.4 lb Comp B	36	220
4.2-inch M329A2	8.17 lb TNT	24	125
105-mm M1	5.08 lb Comp B	24	135
81-mm M374A2	2.1 lb Comp B	20	125
60-mm M49A4	0.42 lb Comp B	12	25

\* Sandbag thickness required to capture all fragments

\*\* Measured distance plus 10% safety factor



# Model - 105mm M1





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# ***Miniature Open Front Barricade (Cont.)***

- ❖ Miniature Open Front Barricade approved by DDESB on 23 February 1999 with several qualifications as detailed in the approval letter. These qualifications include:
  - Only approved for use during intrusive activities, not for intentional detonations or removal of OE item
  - Intended to defeat primary fragments to its sides, rear, and top for unintentional detonation
  - Does not mitigate primary fragments to its open front
  - Is not intended to mitigate overpressure or noise from an unintentional detonation
  - Will not be used for munitions with a TNT-equivalent, NEW exceeding 2.3 lbs
  - Will not be used for intentional detonations
  - Will not be reused after a detonation



## ***Open Front & Enclosed Barricades (Cont.)***

- ❖ Open Front & Enclosed Barricades approved by DDESB on 9 December 1999
  - Approved for use during intrusive OE removal operations
  - Designed to defeat primary fragments resulting from an accidental detonation
  - Are not designed to mitigate overpressure or noise



# ***Donovan T-10 Transportable Blast Chamber***

- ❖ Approved by DDESB 31 January 2000
  - Siting for operations leading up to detonations in the chamber must be considered separately
  - Maximum NEW 13 lbs TNT equivalent or 10 lbs HMX equivalent
  - Fragment producing munitions with diameters up to and including 81 mm may be intentionally detonated in chamber
  - Personnel within 18 ft of T-10 must have ear protection
  - T-10 chamber does not mitigate hazards from chemical, biological or WP munitions